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USAELRDL Technical Report 2309

RAPID VIEWING AND IMMEDIATE VERBAL REPORT IN RECOGNITION OF OBJECTS IN NATURAL ENVIRONMENTS

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August 1962

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RAPID VIEWING AND IMMEDIATE VERBAL REPORT IN THE RECOGNITION OF OBJECTS IN NATURAL ENVIRONMENTS

D. L. Huebner

DA TASK NR. 3D33-18-001-01

ABSTRACT

A pilot experiment was conducted to determine preliminary estimates of interpretation performance at high rates of speed. Various factors of relevance in assessing such performance are discussed, using experimental results to illustrate their application. Requirements for a more comprehensive and statistically reliable experiment are outlined, and suggested areas for further research are discussed. The small number of samples of imagery and subjects made results only suggestive with respect to application.

Two interpreters (subjects) were tachistoscopically shown seven groups of five color slides of different portions of a surveillance area for seven different combined viewing/response time periods. The seven viewing/response time periods were varied in steps between 1 and 60 seconds. When compared with unlimited interpretation time, severe degradation of performance resulted from limiting time to 8 seconds or less. This is consistent with an estimate made of maximum interpretation rate as a function of verbal response rate. Performance was appreciably better at 15 seconds and was best at 30 seconds. The 60-second results were not comparable because of imagery material limitations.

Performance measurement is presented as a complex function of several factors, including conciseness, relevance, accuracy, and rate. These performance measures were applied to the experimental results for illustrative purposes only, and are not to be understood as implying higher reliability than is inherent in the statistically low reliability of the data. The tendency for redundancy of reports to increase with viewing/response time suggests that prior training of interpreters in rapid recognition and reporting would lead to improved performance.

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RAPID VIEWING AND IMMEDIATE VERBAL REPORT IN THE RECOGNITION OF OBJECTS IN NATURAL ENVIRONMENTS

INTRODUCTION

An important problem in the development of efficient surveillance systems is the slowdown of the information handling rate in the imagery interpretation process. Here human detection and identification are applied to the raw system sensor-data by the imagery interpreter, who is serving to transform them into information needed by user personnel. Because of the complexity of these processes, no nonhuman means for performing these functions have as yet been developed. Work on improving performance of these functions by either human or future mechanized means can profit from a quantified and functionally adequate description of interpreter performance. This report reviews some experimental studies that deal with quantified description of interpretation at high rates and reports on an experiment using realistic imagery. In addition, requirements for, and analysis of, problems in the further study of high-performance rates are discussed and approaches suggested.

An experiment was conducted in which interpretation time was measured, and for which certain qualitative performance parameters were estimated. Interpretation rate was measured using imagery of real targets. An unsuccessful attempt was also made to measure independently the time spent on the cognition and on the response portions of the human interpretation process. The difficulties encountered in making the latter analysis are reported in order to help provide a basis for possible further work in this direction.

The primary objective of the present work was to obtain estimates of the amount of interpretation that can be performed under conditions that approximate realistic interpretation situations, with the interpreter pressed for time. The study is essentially a pilot study. The sample of the population of interpreters was small; limited conditions covered by "real" imagery were used; and a small number of imagery samples were employed. Data are, therefore, general; however, they do provide rough estimates of interpretation rate. In addition, they indicate some of the problems in achieving real-time interpretation, and point to some requirements for further study of the real-time problem.

A review of some of the recent literature concerned with studies of interpretation as a function of time revealed that though much good work has been done, many important problems remain. The work has, in general, been directed at developing much-needed basic facts, laws, and equations for describing human perceptual and cognitive functioning.

For example, Boynton and Bush[1] found that with exposure time varied from 3 to 24 seconds, percent correct recognition of a single geometric "rectilinear" target increased only up to 12 seconds. The authors assume that subjects do not process information efficiently during the time periods in excess of 12 seconds. These results were obtained with 16-64 geometric "curvilinear" background figures. Subjects reported their recognitions by pulling one of seven knobs, six of which were shape-coded to correspond to the six different target forms presented, the seventh indicating no detection.

Robinson,[4] using the same geometric figures, performed a similar experiment, but additionally used 0 to 5 target figures, and varied "workload," that is, the complexity of decision required. Three levels of decision complexity were used: (1) minimum--the subject reports presence or absence of targets; (2) intermediate--subjects report either that there are 0 to 3 targets, or alternatively that there are 4 or 5 targets; and (3) maximum workload--the subject reports the number of targets he recognizes, i.e., 0 to 5. Response was by means of pressing the appropriate coded button. Background figures ("numerosity" load) were 8, 16, or 32 in number. In the two experiments performed, time was varied from 1 to 15 seconds. (The second experiment included feedback training for the target form recognition, and warmup training in the performance of the task.) Robinson's results were in substantial agreement with those of Boyton and Bush, little increase in accuracy of recognition being found when time exceeded about 10 seconds.

Miller and Ludvigh,[2] using single spherical target figures in an empty, homogeneous field, measured acquisition (detection) time as a function of visual angle of target. They found that above about 25 minutes of visual angle, acquisition time decreased only slightly with increase of angle, whereas below 25 minutes of arc, time increased greatly with decrease in visual angles of targets. Thus, as target visual angle was decreased from about 25 to 12 minutes, acquisition time increased from about 10 to 75 seconds. Because acuity had been measured as 3 minutes of arc, and because of subjects' comments, the authors attribute the lack of gain in acquisition with time to the disorientation arising from viewing the uniform visual field for more than a few seconds. It is of interest, however, that Boynton and Bush, and also Robinson, using nonhomogeneous fields, got similar results so that the Boynton and Bush assumption that the subjects do not process information efficiently during time periods in excess of 12 seconds seems to fit all of the findings given here.

Steedman and Baker[5] measured speed and accuracy of recognition as a function of size of target. Twenty-four different geometric forms were presented one at a time in a background of about 180 geometric forms. Again, recognition time was found to remain fairly constant when target size was above about 20 minutes of visual arc. Below this size both recognition time and errors increased steeply as visual angle decreased.

Smith[6] measured search time as a function of the number of objects in the display and similarity between target objects and nontargets. Shape, size, and constrast were used as target/nontarget similarity indices. Using a single square as the critical target and circles as nontargets or pseudotargets, mean search time was found to vary from 0.5 to 10 seconds as the number of displayed figures was varied 1 to 1024. When the critical target in a clutter of 256 circular pseudotargets was changed from a triangle to a square, to a pentagon, to a hexagon, mean search time was found to vary from about 4 to 8, to 15, to 40 seconds, respectively. Size and contrast differences with square targets and 256 circular pseudotargets resulted in variation of time for search from 0.5 to 10 seconds.

It is evident that in developing principles of target detection, it has been necessary to use experimental settings that only generally resemble operational tasks. Thus, stimulus materials have been geometric figures of various kinds, response behavior has differed, task requirements have varied

in complexity, and motivation and instructions have been subject to varying degrees of control. Some experiments have not taken prior training into account whereas others have systematically varied it, and in general noninterpreter subjects have been used.

There are many basic questions concerning the usability of this kind of experimentation. There is, for example, the question of what may be called relevance. That is, how valid is it to employ geometric figures to derive conclusions concerning interpretation of real imagery? Though this work yields relationships among the variables tested, to what degree are such relationships a function of the particular figures used, and thus how applicable are the findings to interpretation of real imagery?

There is also the question of representativeness. How representative are the laboratory settings employed? It is true that this is always a matter of degree, inasmuch as all experimental settings, even those involving observation of field conditions, do to some degree alter human motivation of the observed subjects. Yet much of the work is taskwise importantly different from operational conditions.

A further problem is the wide variety of conditions employed in the various experiments. All used geometric figures, but in the five experiments cited, four different kinds of geometric figures were used, and the format employed in providing pseudotargets or clutter varied from a homogeneous empty field to a randomly generated field of figures made up of squares. The number of variables manipulated in one experiment varied over a wide range, and motivation conditions were often uncontrolled, though monetary reward was used to stimulate performance in some experiments. Workload, defined as the number of decisions required, was a variable in some experiments but not in others. There has been little validation of findings in the form of predictive projection of results into operationally representative experiments. Without some formal systematization and testings of the findings, and formal conclusions, the fruitfulness of much of the prior work remains untested.

These observations are intended to indicate that the work that is experimentally sound in terms of concepts being investigated may have only undefined relevance to operational situations. Some of the more recent work noted above is comprehensive and does make predictive generalizations. Yet the problem of validation remains, and the most serious one is concerned with the kind of imagery used.

Much important information has come from this kind of experiment, so much in fact that it would be impossible to handle in one experiment the many different variables examined. The careful control of few variables is essential to generate laws, but does, without additional work, leave a hiatus in the area between laws and concrete applications. The present study allows the many variables of a natural setting to operate "normally," it is hoped, but in any event it gains somewhat in validity what it may lose in reliability. The more realistic conditions employed provide a basis for indicating instrumentation problems, i.e., both in getting more valid experimental data, and in the realization of efficient man-machine combinations.

The conditions involved in the present study included the following. Two trained interpreters were used, one with extensive field interpretation experience in many theaters of operation, the other with little more than a

single course in imagery interpretation, that is, perhaps the equivalent of one year of interpretation in practice. The interpreters were given limited instructions, namely, they were to give flash reports and to work as fast as they could without undue errors. They were given, prior to the trials, a limited opportunity to review maps of the areas which were covered by the slides. They reported their responses verbally, reports later being transcribed from tape. Imagery was coverage of a single maneuver area by means of 35-mm color slides.

The present experiment, using air-surveillance imagery and varied intervals of viewing time, clearly indicates the need for more refined measurements. An attempt was made to perform a representative kind of experiment that would produce preliminary answers and questions concerning "real-time" interpretation of "real" imagery. Many of the problems associated with the more "abstract" experiments cited above arose in the present experiment and in the interpretation of results. The conclusions below specifically list some of these problems with the objective of providing a basis for increasingly more valid and reliable cuts at the experimental objective in the future.

In addition to the major objective of measuring total interpretation time, an attempt was made to determine how much time is consumed by interpreters in cognition, that is, in perception, recognition, and decision time, as distinct from time required to respond verbally. This required two sets of exposures of imagery. Slides were exposed for 1, 2, 4, 8, 15, 30, and 60 seconds with subjects required to report identifications during the exposure time for measuring total interpretation time. But additionally, slides were exposed for the same time durations with the subjects being allowed unlimited time for reporting. The expectation was that as exposure time was decreased, a point would be reached where there would be a difference in the amount of material reported between the limited and the unlimited time conditions. The restriction of reports in the limited time condition would then be a function of the interference of response processes with the time required for cognition. This interference would not be evident for the conditions allowing unlimited report time. The difference in the number of targets reported would be an indirect measure of such interference, i.e., time devoted to response.

However, the experimental design did not adequately meet conditions necessary for producing the performance difference. For example, there was an insufficient number of targets per slide, so that exposure time was not fully taken up. In any event, the unlimited report time series failed of its objective for another reason. The motivation of the subjects, when they were informed of the unlimited report time available, fell off the degree that results were not comparable with the limited exposure time series. This was clearly evident from the greatly increased response latency and reduced response rate when unlimited report time was allowed.

The report is accordingly concerned with data derived from the limited viewing/response time series, which is compared with an unlimited viewing and report time series. These data are those most applicable to simulation of a simple real-time condition of interpretation, in which the rapid flow of imagery would require verbal reporting of critical targets simultaneously with the appearance of a given imagery frame, that is, with no time allowed between frames for reporting.

PROBLEM

The practical objective of this experiment was to find out how fast interpreters can work. Experimental objectives were the determination of interpreter "flash" performance as a function of varied exposure-response time, using photographic imagery stimulus material and trained interpreter subjects. Performance measures include the number of targets identified and report redundancy, and the number of reports in error.

METHOD

Subjects

Two subjects were used. One was a recent graduate of interpreter training, the other had extensive and intensive experience for many years in addition to the formal training.

Materials

Thirty-five slides were used. These were color transparencies of a forest area taken during maneuvers. About 150 slides were examined and a selection of 35 was made which, by cursory inspection, minimized duplication of areas covered. The slides were then sorted into five piles, so that five degrees of forest clutter were represented. Seven groups of five slides were then made by picking at random from the five piles, each group having one slide from each pile.

The slides were projected by means of a Keystone K-511 automatic projector, modified to be triggered so that slides were exposed for 1, 2, 4, 8, 15, 30 and 60 seconds. The timing was triggered externally to the projector by a Lafayette Instrument Company Model 1 Timer, which was modified to allow for selection of any one of the seven time periods by a selector switch. Initiation of a timed interval was made by means of a push button mounted adjacent to the selector switch and operated by an experimenter.

The size of the projected image was 20 inches high by 30 inches wide, and it was viewed at 10 feet. The projection screen was a white cardboard surface ruled with 1/32-inch grid lines spaced $3\frac{1}{2}$ inches horizontally and $2\frac{1}{2}$ inches vertically. Grid sections were serially numbered from 1 to 10 in both directions, beginning at the lower left-hand corner.

A tape recorder was set up for continuous recording of the verbal reports of the interpreters. Announcements of the experimenter were also picked up by the recording microphone.

Procedure

In the experimental series, which was presented first, each subject viewed once each of the thirty-five transparencies. (Alternately interposed were the thirty-five trials with different slides which allowed unlimited response time, and for reasons given above, are not reported here.) The thirty-five response-limited trials were randomized presentations of the seven exposure times, each exposure time being represented by five slides, that is, one group selected as above.

Subjects were informed of the viewing time prior to each exposure. Ten seconds, during which reporting was discontinued, was allowed between the end of one exposure and the beginning of the next.

No instructions concerning the form of the report were given to the subjects. They were asked to respond as though they were giving a flash report in an operational situation based on their own experience. The task of the subjects was thus to report identifiable objects of military significance and to give the coordinates of such objects.

Control data were obtained subsequent to the experimental series, with the two interpreters working together, viewing the same slides, shown in the times series, but here having unlimited time (nominally 5 minutes).

The control data were prepared independently of the experimenter by the interpreters, who worked together and recorded, organized, and then presented the results to the experimenter. The control reports were submitted to the experimenter in typed form, again after no instructions other than to submit operational type flash reports.

<u>Treatment of Data</u>

Inasmuch as the experimental objective was the production of results based upon empirical performance as near as possible to that of an operational-interpretation situation, the experimental variables are presented in comparison with the control data, with primary concern for analytic, comparative results. That is, subjects served as their own controls, and the untimed interpretation results are used as control data. It was thus possible to see the effects of varying the time allowed for interpretation upon the amount and quality of interpretation performance as compared to untimed performance.

Scoring rules were applied to both control and experimental data in order to achieve some leveling of perceptual organization time. For example, five tanks in one location were scored as one I, whereas five scattered identifications of the same kind were scored as five I. This is in keeping with experimental objectives, yielding a more realistic measure of performance than of results.

The rules applied are as follows:

1. Same kind of items in one location

I report	I scored
1 - 5	1
6 - 10	2
11 - 15	3
16 - 20	4
21 - 25	5
26 - 30	6
31 - -	7

2. I's accompanied by "possible," "maybe," etc., are counted as though not qualified by these statements.

3. Word count (W)

a. Location coordinates are counted as two words.

b. UI and APC are counted as one word.

c. All other words are counted as one, regardless of length.

d. All numbers are counted as 1 per digit.

Elements of reports were classified and labeled according to the following categories:

1. (I) Identified objects

2. (V) Objects identified only as vehicles

3. (UI) Objects unidentified except as being of military interest

4. (G) General descriptive statements

5. (L) Locations by coordinates

All verbal (experimental) reports of interpreters were analyzed into the foregoing categories and counted. In addition, total words (W) were counted for both control and experimental data.

The control data (written) were analyzed to find the distribution of identifiable objects (O) among the same seven groups of slides. In addition, the total number of words used in the reporting of each slide was counted.

Caution is advised in reading and interpreting the data reported in this report, particularly with respect to the graphs shown. As indicated in the analysis of the data below, no necessary continuity of the variables displayed in the graphs is intended. The points showing variation of results as a function of time are connected by smoothed curves in order to simplify the reading of the plots, especially to separate the different curves plotted together and to make possible comparison of different sets of data shown on the different graphs. The many psychological effects operating at the varying time periods are not isolated in the simple experimental design employed in this pilot study. An example of this is that it might be assumed that as time was increased in the experimental series, performance would tend to approach the performance in the control (unlimited time) series. Such an assumption is untenable because of the widely differing task and the motivational and subjective conditions operating in the two series.

It is, accordingly, necessary to avoid drawing conclusions from the curves without referring to the discussion in the related portions of the text, and indeed without reading the report as a whole to establish the conditions under which the results were obtained. The report conclusions should, therefor, be restricted to those made in the conclusions proper, and even

these must be understood in the context of the conditions and interpretations of the experiment as described in the body of the report. A glossary of terms and symbols appears in the Appendix.

RESULTS

Data are shown in Table I.

Figure 1 is a plot of the results of the control series, which is used as a comparative criterion for performance in the experimental series. That is, for experimental purpose, it is assumed that with unlimited viewing and reporting time, and with the subjects working together, results represent adequate criteria for completeness and accuracy of target detection and reporting, in this case flash or immediate interpretation of imagery.

On Figure 1 are shown two curves. The solid line depicts the variation of number of targets reported as a function of the same slide groups used in the experimental series for the different time series. The dashed curve shows an additional measure of response, the number of words (W), as defined above.

It is evident that the number of identifiable objects per slide varied considerably in the different slide groups. This variation is such that for the 60-second group, as a minimum, and possibly for the 30-second group as well, there is an insufficient number of identifiable objects (O) to keep the interpreters busy for 60 and 30 seconds during the experimental series. For this reason, it would be expected that for these two groups, reporting would be complete and accurate. The findings indicate otherwise, as will be shown.

It is clear from these curves, however, that for the untimed performance, there is a consistency of reporting such that the ratio of O/W is relatively constant. A mean ratio of 1/6 is thus used as a performance norm, that is, about six words per object were used for identification.

Experimental results are shown in Fig. 2, the solid line being the curve of the variation of the mean number of identified targets (I) per slide as a function of time, and the dashed curve being the mean word (W) response per slide.

The data show that for viewing/report times of 1 to 8 seconds, subjects were able to report even a single target less that 50 percent of the time. No more than a single target was reported by either subject during these presentations. This was so although there was a mean of about 4½ identifiable objects per slide. During the 15- and 30-second exposures, identifications went up to a mean of about 1½ to 2 per slide, respectively. These results are not corrected for errors, and again the 60-second data are vitiated by the few target objects per imagery slide. Total verbal response appeared to be more a function of time than of number of targets reportable or reported.

Figure 3A shows how the mean number of location responses per slide presentation varied with exposure time. In some intervals L's exceeded I identifications because they also apply to reports other than I's. Figure 3B

shows the combined number of vehicular and unidentified responses. The small number of such responses and the shape of the curves signify a minor contribution to the total verbal response.

The curve of Fig. 3C shows a different picture, however. Here is shown a major source of the increasing redundancy as exposure time is increased, namely, the increase in generalized descriptions. Because about five times as many words were used in each G response as in identification reports, this curve understates the effect. Thus, much of the time used in responding to the stimulus configurations in the experimental series was consumed in making general statements, e.g., about the terrain, and other responses, as elaborated below. Some L responses also contributed to redundancy.

A comparative estimate of the effect of time limitations on reports can be made from Fig. 4. Here the control curve shows reports without time limitations, assumed for experimental purposes to be complete and error-free criteria of performance. The lower curve shows the effects of timing. Only correct identifications (Ic) are plotted, reports in error being eliminated. The indicated absolute magnitude of the difference due to time alone between the control and experimental results is perhaps somewhat exaggerated. This is due to the fact that some "slippage" occurred in the control conditions when the subjects at times moved closer to the viewing screen than the mandatory 10 feet of the experimental conditions. The 1- through 8-second reports are corrected by the mean error for all of these reports because there are too few within-slide-group reports to allow individual correction. The 15- and 30-second report groups are individually corrected by the factors shown in Table 2. The 60-second point is corrected by the mean error for all periods, there being too few targets in this group of slides to make any conclusion from this group acceptable.

It is evident under the conditions of this experiment that performance as a function of Ic/O ratio is very low, showing a rise only in the 15- to 30-second range. However, other criteria are useful in assessing the effects of task conditions upon interpretation rate. These are considered below under Discussion.

Table 3 illustrates with some typical examples the effects of time variation upon reports. The sample reports of Table 3A illustrate the incapacity of the interpreter to perform the search, perception, recognition and response functions in the time periods from 1 to 4 seconds. Tables 3A and 3B further show that at 8 seconds and above, adequate identifications are possible, though their number and completeness at the shorter times are limited. Table 3B also illustrates the effect of increased verbosity with time.

In some instances, location numbers are reported in reverse because of insufficient instructions. The 60-second conditions are such, as noted above, as to preclude generalizations because of the very-low average number of objects on the 60-second slides. Slide number 69 (Table 3C) shows an extreme instance of the effect of the extended time of 60 seconds upon reports when observers were asked to report when objects of military interest were absent from the viewed slide.

The data, when analyzed for errors, show similar effects. Below 15 seconds, there are too few reports in each time category to show significant

between-group differences in error rates, as is true for the 60-second group of slides. Thus, only 15-second and 30-second error rate data are comparable. These data are shown in Table 2. Though the subjects worked independently, results for the two subjects are similar. The error percentages for A and B go down from 50 and 50 percent, respectively, in the 15-second period to 9 and 11 percent in the 30-second period. Similarly, overall errors for all seven time periods are in fairly close agreement for the two subjects, that is, 42 and 35 percent for A and B, respectively.

The subjects, however, differ when comparing total correct responses. Because overall error rates are about the same, and because subject A produced about 40 percent more identifications than B (32 as compared with 23), his performance is more effective than B's. Thus A produced one fifth more correct identifications than B, that is, 18 as compared with 15.

In general, the few data make the findings somewhat inconclusive, and it would be desirable for reasons given below to investigate the possibility of qualitative differences in performance at different time periods.

DISCUSSION

The small sampling of subjects and imagery qualify the experimental results primarily as pilot-run findings. It is, nevertheless, possible to accept the conclusions as tentative and, additionally, to attempt the development of explicit requirements for obtaining more reliable experimental results; to elucidate some problems and approaches in getting more valid data; and to identify areas suggestive of needs for further research. The following discussion offers such possibilities in order to make feasible the development of increased understanding of task performance processes peculiar to the rapid interpretation of imagery, and thus to make possible more systematic planning and design of such tasks.

Maximum Interpretation Rate

A limit on interpretation rate when using completely verbal report may be estimated from the control responses. From inspection of these data as plotted in Fig. 1, it can be seen that these reports are concise presentations of relevant military facts concerning the imagery. That is, about six words per identification are consistently used by the interpreters. If the time required for saying these reports is measured, it is found that a moderate rate is about two words (as defined above) per second.

It is possible from this observation to estimate an upper bound for rate of interpretation of imagery. To do this it is only necessary to make the assumption that the verbal response processes are not performed simultaneously with, though perhaps interpolated with, cognitive processes. That is, total interpretation time must be greater than the verbal response time. It includes the cognition time required for visual search, perception, recognition, plus the time for transformation of recognized object categories into verbal response categories.

As noted under the control conditions of this experiment, approximately six words were used to describe each identification. At the rate of two words per second, this would impose a lower bound of 3 seconds per identification under the best of possible stimulus conditions and omitting pre-

response search and cognition time. However, this figure is otherwise somewhat optimistic as well, as can be seen from comparing the content of flash and immediate type reports illustrated in Photo Intelligence Reports, issued by U. S. Army Intelligence School.[7] These are shown in Table 4, and may be compared with the items in the untimed results shown in Table 3. The mean number of words per identification for flash and immediate reports is about 15 (pp. 8-9) as compared with 6 in the present experiment. The additional 9 words in the latter case are due primarily to two considerations. One is the more precise location coordinates that involve five additional numbers (words).

Also, control data in the present experiment omitted such terms as "active" and "camouflaged," "in open field," and "occupied." These would fit into what are called G, or general responses in the experimental reports. In the present experiment, however, these consisted largely of less specific information of little value, evidently due to the omission of prior training of subjects in high-speed interpretation.

The more representative and complete reports of reference[7] thus indicate a minimum interpretation time of approximately 8 seconds per identification object. Various considerations that would influence this figure in an upward direction include the following: Imagery quality, target subjective probability (expectancy) and objective probability, training and experience of interpreters, and target density.

Certain considerations could affect the estimate in a downward direction. One is target redundancy. The word-count approach assumes equal information value of all words. However, if an interpreter were observing a series of imagery frames, it is likely that there would be some repetition of targets and frames, in which case it would only be necessary for him to be silent or to say a single word such as "same" to indicate repetition of all 15 words of immediately previous detections, or possibly to say a number previously coded to describe targets. This would reduce the number of words required to report objects, as well as simplify the cognitive work. The effect would be to increase the interpretation rate in a way which requires an investigation into what might constitute a realistic sequence of redundancy in typical imagery, as discussed in the conclusions below.

It might appear that because the 8 seconds per identification is based upon a moderate speaking rate, it could be speeded up on this account. In fact, as noted, this rate probably overestimates the rate for most real conditions. This rate presupposes that there is no search, perceptual, or recognition difficulty so that the output verbal response stream can be fed without hesitation. This rate should be considered as the peak verbal reporting rate. Any realistic estimate of maximum interpretation rate would require specifications of the following variables:

1. Imagery entropy; this general term is intended to include many considerations involved in the stimulus conditions. These include the effects of redundant imagery, camouflage, resolution, and familiarity of objects to be identified.

2. The effects of selection, training, and task instruction, including availability of interpretation keys on the quality of interpretation performance.

3. The duration of the interpreter's duty period; that is, an interpreter can perform at high rates only for short time periods.

4. Performance criteria, that is, higher rates could be achieved if more errors are allowed.

Any estimate of interpretation rate would have to be stated in terms of the particular characteristics of the imagery, personnel, task, and performance criteria involved in a given situation.

Kinds of Response

The wide variation of kinds of response in the experimental series suggested one possible treatment of the data. The interpretation task may be considered as a conversion of spatially distributed light-intensity gradients into verbalized responses having associated meaning categories based upon prior agreement on relevant selection. This process thus basically involves selective detection of classes of organizations of stimulus material, and response in terms of associated audible or written output. This may be considered as an entropy reduction task in which the rate and quality of performance are functions of stimulus variables; of task variables, such as time and instructional set; and of the relation of responses to appropriateness of organization of stimulus objects.

Accordingly, the different verbal response categories in the experimental results may be arranged in order of report adequacy according to the following hierarchy of information value.

This tabulation covers a rather extreme variation in kinds of responses, but is intended to be comprehensive enough to deal with all likely categories. Items 1 and 2, identifications and locations by coordinates, represent the most concrete responses which, under idealized conditions, would be the only reports. In the experimental series and the Intelligence School samples, many additional kinds of responses were given by the interpreters which fit into the remaining categories. Category 8 represents no information value, and 9, the error category, negative value.

Numbers 5 through 7, the "Vehicular" through "Qualifiers," are of decreasing information value in the order mentioned. Of these five categories, 3 and 4, the "Vehicular" and the "Unidentified," belong essentially in the number 1 or "Identified" categories but are indicative of lower degrees of confidence in target recognition. Their low frequency of occurrence in experimental responses makes them relatively low in importance in the results in the present findings, though their frequency may be expected to be a function of the imagery situation.

Category 5, "Descriptives," appeared fairly frequently in the interpreter responses, but appeared to have little value inasmuch as it was usually associated with "General" statements, item 6, and thus have little information value. In the Intelligence School Report cited above, terms such as "active," "parked," "camouflaged," and "occupied" appear. These are associated with specific identifications, category 1, and therefore have meaningful relevance to identifications. The experimental responses of this kind appear to be time fillers rather than responses having significant information content. Category 7 involves qualifiers that suggest, such as do 3 and 4, indications of confidence in reports.

Number 8 represents pure fill, evidently indicating a misunderstanding of the task, inasmuch as these responses appear in the longer time periods, adding grammatical neatness but no usable information about imagery objects.

Responses of the 6 through 8 categories, representing what might be called excess production responses, thus have something in common with the errors listed in that they involve responses that are not significantly related to the stimulus character or formal task requirements. Causative considerations include poor control over selective perception and response by the subjects, and the informal characteristics of the stimulus conditions and the task. These involve the implicit suggestive character of the task, motivational conditions, and instructional open ends.

Errors

The errors described in the Results, as shown in Table 2, were scored in the following way. Identifications were counted as errors if it was clear from the control series that either no object or an object other than one reported in the experimental series was present in the location specified. Table 5, however, presents under category 9, a more detailed, fourfold analysis of the kinds of possible errors.

Table 6 shows an illustrative example of this breakdown, illustrating some relationships among errors, conditions, objects, and responses. Column 1 indicates three kinds of contextual settings in which objects may appear. In practice, combinations of the three are likely. Column 2 shows five possible categories of stimulus object clarity which could potentially be responded to as "tank." Column 3 gives a breakdown of kinds of error as listed in Table 5.

Thus (a) involves a substitution error as defined above, one military object being called another; (b), inventive error, in that the stimulus object is a nonmilitary man-made object; (c), inventive, in that the stimulus object is a natural object; and (d) an imaginative production, no object in any way similar to the one reported being present. Column 4 is a breakdown of kinds of error according to the substitutive/inventive dichotomy.

The fourfold breakdown of errors indicates certain directions for further investigation of the causes of errors in interpretation. These are outlined in the Conclusions. In any case, it can be seen from column 2 that in terms of stimulus conditions, errors vary in degree rather than in kind. This fourfold classification makes possible distinguishing between the kinds of error of importance to the interpretation task. From the point of view of responses, it may be necessary only to distinguish between substitutive errors and all other kinds as inventive. However, further clarification of the sources of error is essential to make possible prediction and control of errors. From this point of view the listing in Table 6 is a compromise.

The table illustrates only those errors which may be considered as "upgrading," or "equal" errors. Not shown are errors of omission or "downgrading," for example, a tank may be the stimulus, but a truck, or natural object, or nothing is reported. These may be considered as downgrading errors in that the importance of a stimulus object is reduced in the response; whereas in the errors tabulated, the functional significance or specificity

of the object is exaggerated. In general, it would be expected that downgrading errors are likely to have more serious consequence inasmuch as they may lead to underestimation of object importance and consequent underplaying of user decisions and actions. This suggests that for purposes of application, it may be advisable to additionally categorize errors as (a) positive or upgrading, (b) substitutive or equal, and (c) negative or downgrading. This classification makes possible an operationally useful approach to the many variables shown in the table, so that confusion between error effects and sources may be avoided. This would appear to be necessary in order to make adequate investigations of error sources that would lead to techniques and procedures resulting in reduction of errors.

Performance Factors

One problem in making measures of recognition rate is the criterion question. The results as reported above simply indicate the variation of number of objects identified and the number of words as a function of time. However, without some explicit criteria of performance, the possible applicability of such results is limited. Similarly, the stimulus and response variables require explicit stipulation if results are to be translated into operational application. The effects of the number of identifiable objects, the efficiency of verbal response, and the accuracy and completeness of identification are some of the variables to be taken into account in assessing the effectiveness of interpretation at various rates.

The development of performance measures was considered as relevant to this problem. These can lead to possibilities for standardization and quantification of measures of interpretability effectiveness. The measures were applied to the experimental data in order to illustrate their function. Because the data are weak in precision due to the exploratory nature of the study, the performance measures yield relatively ambiguous results. However, as will be shown, they do make possible fairly concise presentation of the variation of various effects that contribute to and result from interpreter performance as a function of time.

Five performance factors are considered as particularly relevant.

1. Stimulus-Response (S-R) Efficiency. This is a measure of the identification performance, that is, the ratio of correct identification to identifiable objects, or Ic/O. In the experimental data, these are the experimental and the control identifications, respectively, as shown in Fig. 4, with errors subtracted from the experimental identifications. The plot of the Ic/O ratio is shown as the solid-line curve in Fig 5. Stimulus-response efficiency varies from a low of 0.04 for the 4-second series to a high of 0.53 at 30 seconds. That is, at best, about half of the objects on the slides were identified without error. In general, S-R efficiency appears to increase only when viewing time exceeds about 8 seconds.

2. Accuracy. This is a measure of the degree to which performance is error-free, and is the ratio of correct identifications to total identifications, or Ic/I. This is shown in the broken-line curve of Fig. 5. The range of accuracy varies from a low of 0.32 during the 2-second series to 0.90 at 30 seconds. That is, at high recognition rates, 7 of 10 reports were in error; at 30 seconds, only one in 10 was in error. There was little

difference between the 2-, 4-, and 8-second accuracy results, as was true for the total number of objects identified. However, accuracy at the 1-second rate was unusually high, being 0.74.

Figure 6 shows the variation with time of overall man-machine effectiveness of interpretation performance in the experimental series. These curves illustrate the results in terms of revelance, rate, and a factor which combines the effects of efficiency and accuracy, which were separately shown in Fig. 5 and discussed above. The three additional factors follow.

3. Response Efficiency. This is an estimate of the relevance of the interpreter's report, and is measured in terms of the ratio of the usable response to the total response, that is, total response words minus redundant terms divided by the total words, or simply relevant descriptive words over the total words, Wd/W. Relevance of descriptive terms is, as based on the Photo Intelligence Reports reference, taken to include four subcategories:

1. The numerals signifying the number of objects identified (<u>1</u> integer).
2. The words naming the objects identified (<u>2</u> nouns). These are listed in Table 5 as I.
3. The descriptive terms that modify the named items (<u>4</u> prepositional, adjectival, or verbal words) listed as D in Table 5.
4. The location coordinates (L) that report the position of the identified object (<u>8</u> symbols - 2 letters, 6 numerals).

The 1, 2, 4, and 8 count of subcategory terms per report are derived from averaging the number of such terms appearing in the sample flash and immediate reports given in the reference cited. This is a total ratio of 15/1. The difference between this and the 6/1 ratio found in the control series indicates an attempt on the part of the interpreters to be overly concise in the control reports. The reports in the experimental series were more complete, though they also included more redundancy terms, i.e., those labeled as general statements, qualifiers, and chatter in Table 5. No analysis in terms of this kind was made of the experimental results inasmuch as no prior training was given to interpreters in restricting responses to these specific categories. However, the dotted curve in Fig. 6 shows a plot of "nonredundancy" i.e., relevance, the curve of the ratio of descriptive words, Wd, to total words, W. A gradual decline of relevance with time is evident. No indication of adequacy of descriptive terms is indicated, e.g., the short-time reports are likely to be lacking in location coordinates. An adequate measure of response efficiency would show the variation with time of the various subcategories of response.

4. Net Rate. This is an estimate of the rate or speed of correct interpretation, measured as correct identifications per unit time or Ic/t. This is plotted as a solid-line curve in Fig. 6, with the ordinate in seconds shown on the scale to the right. As with accuracy, the 1-second rate results are unusually good compared to other short-time performance. This may be a random occurrence due to small sample size, or it may be at least in part due to heightened interpreter motivation upon being alerted to the 1-second, the shortest, trial coming up. In any event the number of reportable objects in

the slides is probably insufficient to make a meaningful comparison of rate results in the various time periods.

5. Combined Performance Factor. This represents a composite of factors 1 and 2, S-R efficiency and accuracy. This is defined as the product of the Ic/O or stimulus-response efficiency, and Ic/I or accuracy. This reduces to Ic^2/IO, which is plotted in Fig. 6 as the broken-line curve. As with the component factors if performance is perfect, this net performance factor is equal to 1.0. Missed identifications or incorrect identifications will individually or in combination lower the numerical value of the performance factor below the level of 1.0. The combined effect of the two factors in the series illustrates the poor net performance at other than the 30 record time periods.

The relatively good results in the 30-second series is a function of the combined effects of accuracy and efficiency. Performance in the other time periods is effectively reduced by low accuracy or by missed identifications or by both. The reliability of the 60-second data is vitiated by the few objects per slide for this group. The average of one object per slide with 60-seconds for viewing-response yields the expected result of low identification rate. It is to be noted, however, that neither accuracy nor efficiency is unusually high despite the long time allowed for the 60-second performance, indicating again the effects of motivational problems on task performance. A further indication of this trend is the decline in relevance of reports with increased time for viewing and reporting.

Thus overall performance, to the degree that results can be generalized from the small-scale experiment, was low except for the 30-second period, in which performance was much better, though even then only moderate.

The foregoing use of the five factors serves to demonstrate the methodology of their application. The combined performance factor is such as to directly indicate net output of the interpretation. When considered with the rate and relevance factors, a reasonable measurement of interpretation adequacy is provided. The separate presentation of the two components, accuracy and proportion identified (S-R efficiency), serves to indicate the source of the falloff in performance. In addition, the response efficiency or relevance measure serves to indicate the degree to which performance is affected by interpreter adherence to reporting only relevant information. This is thus a measure of the results of instruction and training.

It is likely that simultaneous maximization of the various factors is not possible, regardless of improvement in performance achievable through training and instrumentation. It is also likely that different operational situations would require different emphasis on performance. That is, one may involve a high payoff on accuracy, another situation may place a premium on completeness of report, and so on.

In a comprehensively designed experiment using more representative imagery, plus a broad sample of imagery and interpreter subjects and with other variables kept under control, it would be possible to generate data which would show how the various performance variables interact. From this it would be possible to generalize to operational applications so that meeting of varied system requirements might be optimized. Suggested requirements

for such an experiment are outlined below.

CONCLUSIONS

Recommendations for Research

Many questions with respect to the rapid recognition of objects require further research other than that necessary for determining performance variables. Research into specific problems not now understood would make it possible to improve performance and to anticipate and circumvent performance weaknesses. Some examples follow.

1. Investigation of the effects of training and instruction upon speed of interpretation. It is reasonable to expect that performance could be significantly speeded up by designing the task to take into account the unique characteristics of the high-speed requirements. The need for rapid search and restriction of redundancy required to maximize interpretation rate can be best achieved by experimentally determining performance, training, and instruction techniques that meet these requirements. An experiment specifically designed to develop such an optimized task could lead to considerably enhanced interpretation rate.

2. Another area of investigation is that of coding. This would involve the development of a systematic coding scheme that organizes the kinds of objects to be reported into easily learned coded categories in which objects are represented by concise symbols in the form of words or numbers. This could result in the saving of time in reporting and communicating the names of objects identified. If prior learning of a coded response scheme were provided for, it would be possible to reduce minimum time for responding by coding target description words into smaller packages. Targets could be categorized into a phonemic, letter, or number combination code such that a small verbal response stood for a longer one. This would have the effect of reducing response time by a factor perhaps of 2. This could be achieved for manual response in lieu of verbal response by using a key-set scheme. However, there does not appear to be any known reason why manual response should exceed verbal response rate. In fact, Quastler[3] and others have shown that maximum information rates for verbal speech output and manual performance, as typing and piano playing, are roughly equivalent, speech being slightly faster than typing.

3. Another investigation would thus involve the comparison of verbal versus manual response in the reporting of identifications. Although there appears to be no reason why manual response using, for example, a key-set scheme should be faster provided verbal responses are coded as efficiently as the manual ones, another difference remains as a possibility. When reporting at high rates, there is inevitably a crowding of the functions of search, recognition, verbal categorization and response. Under such conditions, a difference in performance is possible as a function of whether verbal or manual response is used. It would be possible to predict interference effects between the mental process of verbal categorization and manual response; that is, an added dimension of coding is required for the manual key-set response. However, it is possible to interpret this with an opposite conclusion, namely, that there would be less interference because the processes of verbal categorization and manual response may make possible parallel performance of these two

processes, thus reducing total report time. This is an experimental question for which an answer could be obtained with a small-scale experiment involving simple learning. It is possible that the difference in time, if any, between responding verbally and manually would be so slight as to be trivial with respect to the total search, cognition, and response time.

4. Another investigation essential for determining the special character of the task involving interpretation at high rates has to do with redundancy. Two requirements exist here. One is concerned with the determination of realistic estimates of redundancy. In order to make realistic estimates of maximum interpretation rate, it is necessary to have experimental imagery involving target redundancy equivalent to that obtaining in an operational situation. It cannot be assumed that there would be a linear relation between target density and interpretation rate. It is likely, as a minimum, that with very-high and very-low densities, special problems arise such as confusion and boredom, respectively. It would, therefore, not be possible to extrapolate from a normal or average range of density to high performance rates. Further, such considerations raise a question concerning the real possibilities of rapid changes that occur in target concentration and their effects upon performance, and how such effects might be minimized.

5. A second investigation of the redundancy question needed for maximizing the interpretation rate is concerned with the techniques of presentation of imagery. This involves the determination of the optimum characteristics of a task using a variable speed imagery film transport. The technique would involve the speed of imagery presentation manually controlled over a wide range by the interpreter. Two parameters would be varied--the range of transport speeds allowed the interpreter, and the redundancy of the imagery. The latter would be varied over a range in accord with the findings of the just previously outlined study to encompass a typical range found in operational situations. The effects of the allowable range of transport speeds upon errors and detectability would be measured. From this would be determined practicability of using such an approach for screening or for interpretation, and allowable speed ranges. Additionally, the effects of related variables such as instructions and methods of search and reporting would be determined.

6. In addition to factors directly associated with increased interpretation rate, there are special problems of errors generated by acceleration of performance, which can be minimized if investigated. It is evident that at high performance rates, motivation, suggestion, instruction, and imagery context cues will have effects upon error rates which are quite different from effects prevailing at normal interpretation rates. It is also likely that operational periods would have to be shorter or broken up with rest periods. An investigation of such problems in high rates of interpretation is essential if valid maximum rates are to be determined, that is, performance with a specified limitation on errors.

7. Another investigation needed to clarify the high rate error problem is suggested above in the discussion of Table 6. Column 3 of this table is a fourfold classification of errors based upon three categories of stimulus conditions. To deal with preventing these errors, it would be necessary to know their proportional frequency as well as the payoffs consequent upon their occurrence. In this way, decisions concerning the design of the task and

associated equipment might be explicitly designed to have maximum gains in system performance. This would involve ascertaining the empirical probabilities of the incidence, in operational imagery, of the various combinations of stimulus objects and their contextual settings. In this way the kind of error and its likelihood in relation to various operational conditions would be determined and measures for such error prevention optimized.

8. An important question concerning what constitutes operational imagery arises with respect to these investigations. This is indicated in the classification of target settings shown in column 1 of Table 6. The three different settings lead to different kinds of error possibilities. This being the case, it is essential to have a distribution of experimental imagery which realistically represents the various operational situations. In particular, the second category, man-made nonmilitary environment, is likely to have characteristics for errors in recognition which are more serious and frequent than the other categories. The interspersing of military objects in an environment of man-made civilian objects requires that such objects, characterized by contour properties similar to the civilian environment objects, be discriminated from the latter. This will lead to a higher error rate, and to results which may have more serious consequence than errors occurring when military objects are observed in a natural environment. This is of particular interest because of the greater difficulty in obtaining, for experimental purposes, imagery that involves military objects in a civilian, for example industrial, setting.

9. One investigation basic to rate and errors studies is that concerned with the payoff and criterion question. The foregoing recommendations for studies have dealt with the stimulus environment, the stimuli alone, with methods of responding to detection, with the role of the task organization, and with motivation and suggestion. However, without some organized specification of the system payoffs for the occurrence of various rates and errors in relation to the operational setting, the possible stipulation of such rates can have little possibility of being operationally useful. As a minimum it is necessary to know what combinations of rates and errors are allowable and under what conditions. If such criteria were stated, it would be possible to take experimentally determined data and specify possibilities for performance in operational applications. What is required here is a systematic statement of the function required to be fulfilled by the interpretation subsystem in terms of the measures employed in defining the subsystem.

Experimental Findings

The experimental conclusions are based upon a largely qualitative analysis of the data, generalizations of such nature being sufficient for the recommendations to follow, and necessary because of the character of the experimental design. Several trends are clear. These conclusions should be considered in light of the aforementioned note of caution regarding possible overgeneralization of the findings.

1. The effects of timing on the performance of interpretation in the experimental series are marked, and do not involve mere quantitative variation of output response, i.e., in the number of objects reported as a function of time of slide exposure. When the timed response is compared with the nontimed, it can be seen that the number of response words, W, per identification, I, far exceeds the necessary minimum for adequate description. The

efficiency of the interpretation response processes as measured by the reciprocal of this W/I ratio is low for the times series, and the data show a decrease of efficiency with time.

2. The number of I (identified object) reports below the 15-second time interval is insignificant. It evidently took 15 seconds as a minimum to perform the necessary search, perception, cognition, and response functions required for making flash reports of the kind required in this experiment. Whether special training could alter these results is a question for further investigation, though improvement is to be expected.

3. Errors averaged around 50 percent. Experimental conditions were such as to make error variations with time of questionable reliability. For example, the error scoring was confounded by the grouping of I scores and by the problem of unequal difficulty of target detectability.

4. The increase in redundancy, that is, reports consisting of nonspecific descriptive terms, is due to the tendency to produce more very loose qualifying terms and descriptive statements of a most general sort such as those concerned with gross terrain features. The additional time that was available over that necessary for reporting the I's and L's in the 15- and 30-second exposure was not solely used to detect and report more targets but also to give loose descriptions, G's (generalized statements), and even looser qualifying words. In the 60-second series, where few targets were present for reporting, there is a further increase in redundancy over the shorter intervals.

5. It is reasonable to consider that under the pressure of time, the subjects perceived their task in part as that of "keeping busy" or producing the most "W" output during the time allowed for viewing/response report. It would appear that when they had to make a trade-off between temporarily halting verbal response in order to search for targets, and reporting gross features, they choose the latter. Inasmuch as this was a novel kind of situation to them and they were not instructed on procedure, these results are not unexpected.

Recommendations for a Follow-Up Experiment

The data and the negative findings suggest that a follow-up study would lead to more reliable and valid data.

The following are some requirements for a more comprehensive study of the effects of time reduction on interpretation performance.

1. The use of slide groups, or transparency imagery, in which approximately equal numbers of targets appear.

2. Slides and slide groups among and within which detection and recognition difficulties are approximately equalized.

3. A sufficient number of targets per slide to allow for continuous reporting.

4. In addition to the random variation of presentation of the different viewing/response time periods, experimental procedures in which subjects are not informed as to how long a slide will be viewed.

5. A reconsideration of the time information problem posed in 4. It may be that informing the subject of interpretation time to be allowed before each presentation may be more representative of operational conditions.

6. Repeated instructions that subjects are to work as fast as they can with as few errors as possible.

7. In addition to 4, 5, and 6, much greater attention to the motivation question in the design in order to equalize motivation among slide groups and to make possible a more typically represented operational setting.

8. Reconsideration of the scoring rules applied in this experiment on the basis of the present results and in terms of the objectives of the new experiment. Perhaps visual research data could be used to work out scoring rules to equalize time values of detection of different numbers of similar and different targets, in the same or different locations.

9. An investigation of the effects of prior training on performance, especially in terms of concise descriptions and procedure.

10. Assimilation into the new experiment of some instructional rules derived from the findings of the present experiment. As a minimum, subjects should be trained not to produce reports in response to time available, targets being absent.

11. Part of the new experiment might include use of a coding training such that subjects are taught to respond only in a limited number of categories even when stressed by insufficient or excess time. Such a code might allow only I, V, UI, and L responses or it might allow categories described under "Response Efficiency" above, the 1, 2, 4, 8 ratio of number, I, D, and L.

12. If possible, the number of presentations of imagery per time period should be increased by about tenfold, and the number of subjects increased sufficiently to allow for statistically reliable findings. Other procedures and conditions should likewise be tightened up to further this objective.

ACKNOWLEDGMENT

The able assistance of Dr. Erwin Biser, Messrs. Lawrence Dennis, and Harold Freedman is hereby acknowledged with gratitude.

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GLOSSARY

The use of terms and abbreviations in this report comes from three sources, two being the parlance of photo interpretation and psychology. A third is a usage of terms introduced in this report to deal with the kind of events investigated. This glossary, when combined with description of terms in Table 5, is intended to define the terms and symbols used in dealing with the report data, whatever their origin.

W -- words. A count of the words used by the subjects in reporting the interpretation identifications. The method of scoring the count is described under "Treatment of the Data."

Wd -- words, descriptive, i.e., nonredundant, relevant words.

O -- identifiable object. These are the so-called "truth" data employed, i.e., the objects identified under the unlimited viewing/response time of the control series when the two subjects worked together.

APC -- Armored personnel carrier.

VERBAL RESPONSE -- Verbal report. The sole interpretation report medium used in this study. Manual response is possible, e.g., for reporting location coordinated, but was not used in this investigation. The possible use of manual response is discussed on pages 17 and 18.

VIEWING/RESPONSE TIME -- The experimentally varied time period during which interpreters were reporting while the imagery slide was shown, and reporting only during this time.

t -- time, in seconds. The experimental time periods, 1, 2, 4, 8, 15, 30 and 60 seconds, indicate the viewing/response time which was independently varied. The same seven numbers are used with the control data to indicate the same slide groups as used in the experimental series. In the control series, time was, of course, not a variable.

PEAK REPORTING RATE -- An estimate involving verbal response only, based upon the assumption that interpretation rate cannot exceed, for practical purposes, the interpreter's capacity to report. Using a moderate verbal response rate of two "words" per second, it is estimated that for the six words used in the simplified reports of the control series, an approximate peak reporting rate is 3 seconds per identification. Using the operationally more realistic criterion of fifteen words per identification,[7] a figure of about 8 seconds per identification as peak reporting rate is derived. See the discussion in the text, pp. 10 - 12, concerning the problems in applying this estimate to interpretation situations.

GANZFELD -- A completely homogeneous visual field, to which perceived form may or not be added by projection of the observer, depending upon the nature of the task, prior training, and motivational and subjective conditions.

S-R EFFICIENCY -- Stimulus-response efficiency.

Ic/O, the ratio of the number of correct identifications to the number of identifiable objects. See p. 14 for discussion.

ACCURACY -- Ic/I, the ratio of the number of correctly identified objects to the total number of identified objects. See p. 14.

RESPONSE EFFICIENCY -- Relevance or nonredundancy. The ratio Wd/W, i. e., relevant descriptive words divided by total words. See p. 15.

NET RATE -- The ratio Ic/t, the number of correct identifications per unit time in seconds. See p. 15.

COMBINED PERFORMANCE FACTOR -- The product of S-R Efficiency and Accuracy as defined above, or Ic/O times Ic/I, or simply, Ic^2/IO. See p. 16 for discussion.

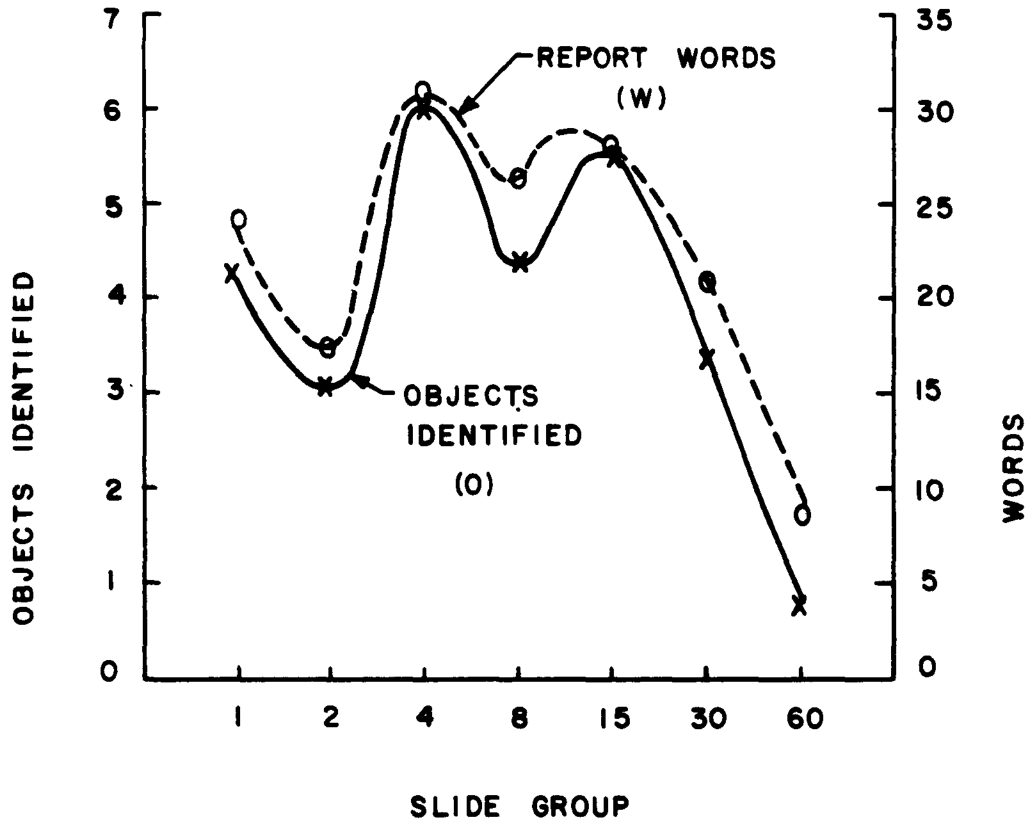


FIG. 1

MEAN NUMBER OF OBJECTS IDENTIFIED AND RESPONSE WORDS FOR DIFFERENT SLIDE GROUPS IN THE CONTROL (UNTIMED) SERIES.

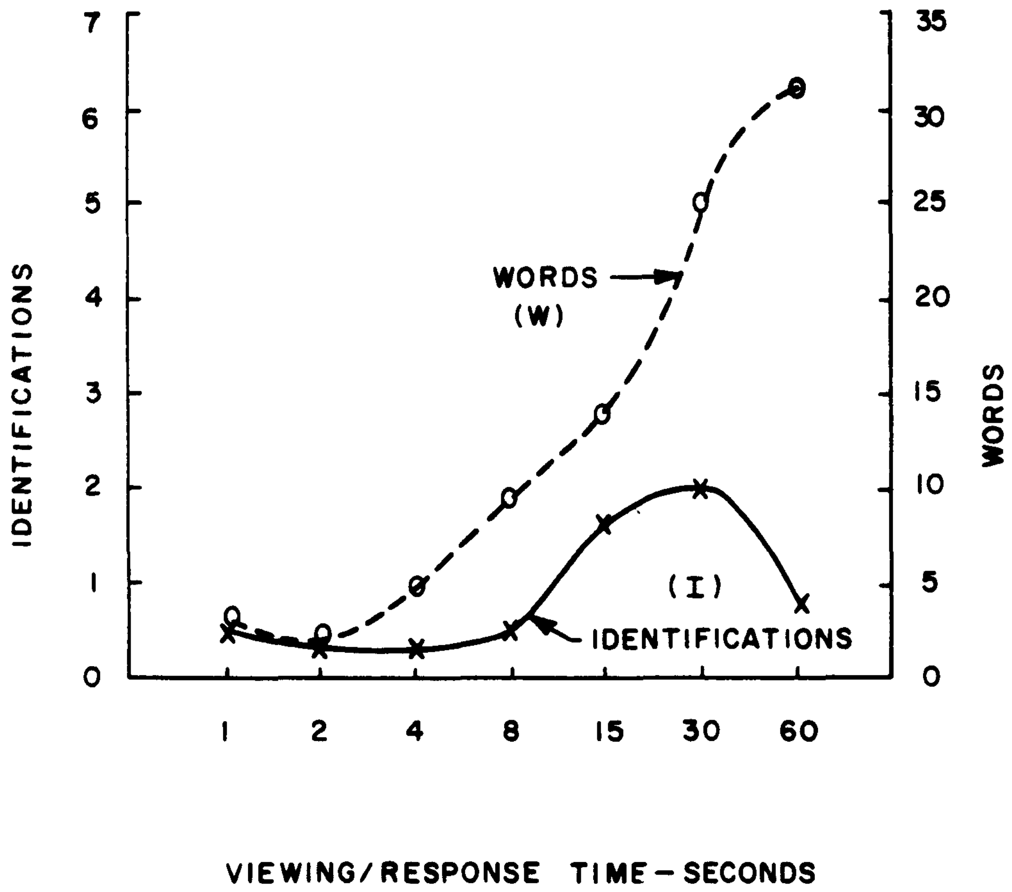


FIG. 2

MEAN NUMBER OF IDENTIFICATIONS AND RESPONSE WORDS FOR THE SLIDE GROUPS IN THE EXPERIMENTAL (TIMED) SERIES.

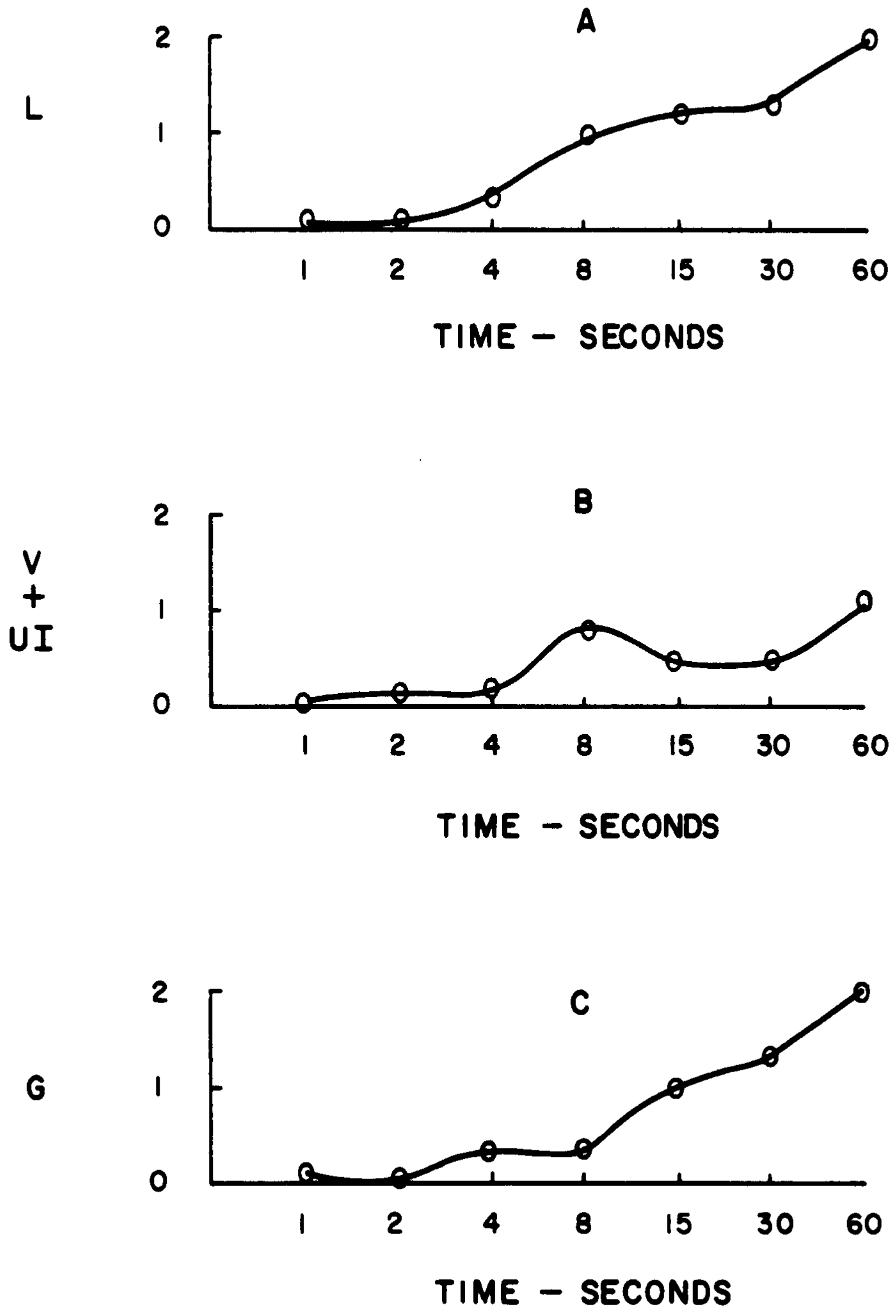


FIG. 3. VARIATION OF DIFFERENT KINDS OF RESPONSES AS A FUNCTION OF VIEWING/ RESPONSE TIME.

A. LOCATION (L) RESPONSES

B. VEHICULAR (V) AND UNIDENTIFIEDS (U) RESPONSES COMBINED.

C. GENERAL (G) RESPONSES

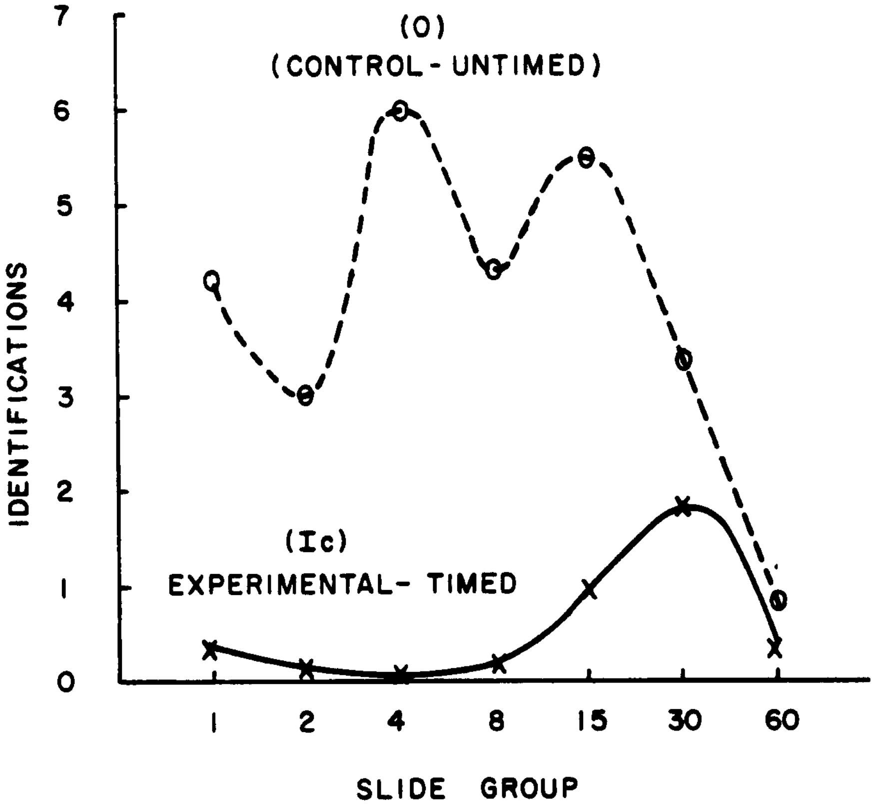


FIG. 4. COMPARISON OF CONTROL AND CORRECT EXPERIMENTAL IDENTIFICATIONS.

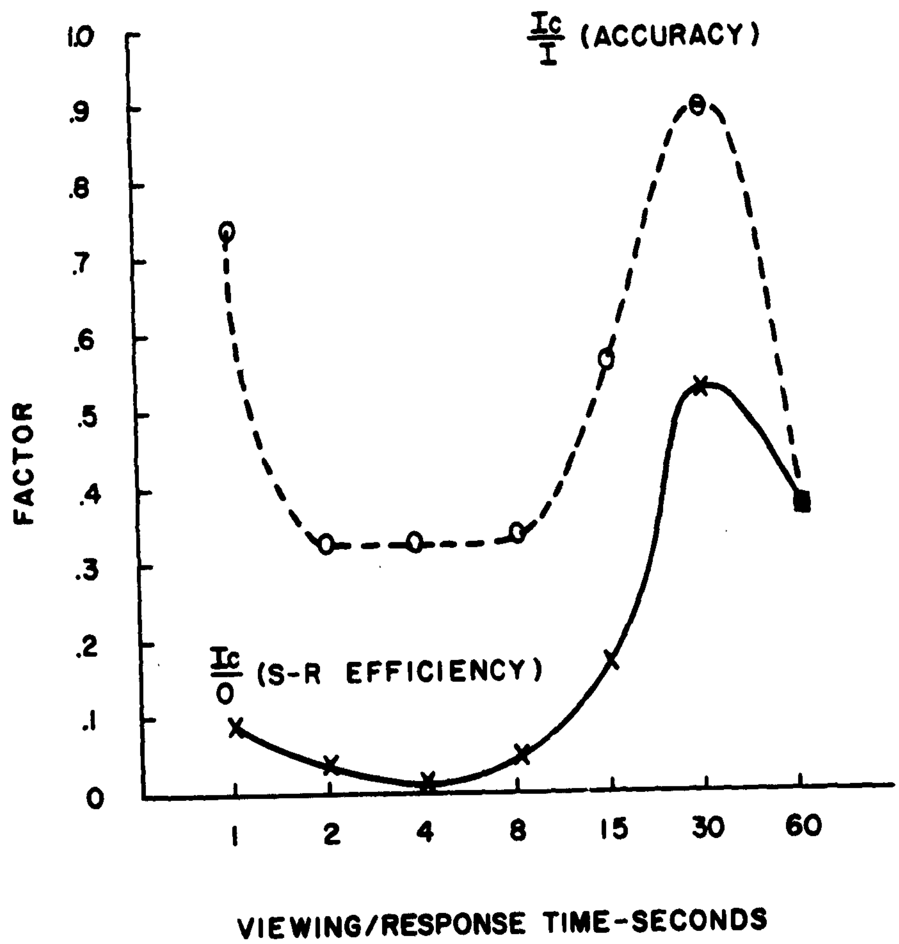


FIG. 5 EXPERIMENTAL SERIES-ACCURACY AND S-R EFFICIENCY.

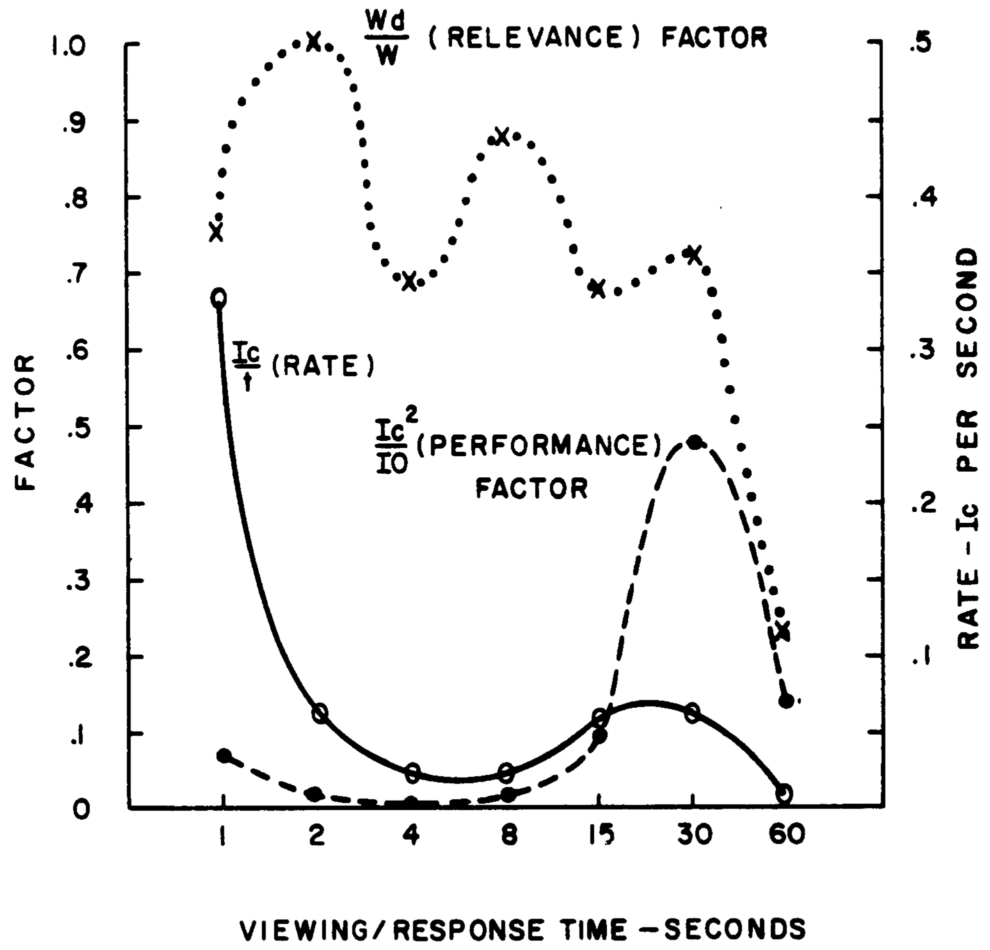


FIG. 6 EXPERIMENTAL SERIES — RELEVANCE, RATE, AND PERFORMANCE.

TABLE I

MEAN NUMBER OF DIFFERENT KINDS OF RESPONSES IN THE CONTROL AND EXPERIMENTAL SERIES FOR THE SEVEN SLIDE GROUPS

t	O	I	Ic	L	V+UI	G	We	Wc
1	4.2	.5	.37	0.1	0	.1	24	3
2	3.0	.37	.12	0.1	.12	0	17	1.9
4	6.0	.3	.1	0.3	.2	.3	30	4.9
8	4.3	.5	.17	1.0	.8	.3	25	9.5
15	5.6	1.6	.9	1.2	0.6	1.0	28	14
30	3.4	2.0	1.8	1.3	0.6	1.3	21	25
60	0.8	0.8	.3	2.0	1.1	2.0	9	31

t - TIME, SECONDS, IN EXPERIMENTAL SERIES. IN CONTROL SERIES, t INDICATES SAME SLIDE GROUPS AS EXPERIMENTAL, BUT UNTIMED.

Ic - ITEMS IDENTIFIED CORRECTLY

We - THE MEAN NUMBER OF WORDS USED IN REPORTING EXPERIMENTAL SERIES.

Wc - THE MEAN NUMBER OF WORDS USED IN REPORTING CONTROL SERIES.

OTHER HEADINGS AS IN TEXT; TABLE 5, AND GLOSSARY.

O AND Wc ARE CONTROL, ALL OTHERS ARE EXPERIMENTAL RESULTS.

TABLE 2

MEAN ERRORS - TIMED SERIES - 2 SUBJECTS (A & B)

TIME (SECONDS)	IDENT'S		ERRORS				
	N		N		PERCENT		
	A	B	A	B	A	B	A & B
1 - 8	0.5	.31	.31	.12	60	40	50
15	2.0	0.8	1	.4	50	50	50
30	2.2	1.8	.2	.2	9	11	10
7 PERIODS	1	.74	.42	.26	42	35	38

TABLE 3A

COMPARISON OF UNTIMED AND TIMED REPORTS

UNTIMED (written) (2 subjects working together after timed series)		SLIDE No.	TIMED (verbal) (Independent reports of subject A and subject B)
1 Gun emplacement, empty 2 Vans 1 Truck, 2½ ton, w/water trlr on the road 1 Truck, 2½ ton, w/poss water trlr*	91 21 34 44	27	1 Second (A) Road (B) There is
1 Truck, 2½ ton 1 Truck w/water trlr UI equipment near truck	55 & 52 62 55	5	2 Seconds (A) One tank (B) (no answer given)
1 APC ea travelling 1 Truck, 3/4 ton	56 & 64 37 & 47	41	4 Seconds (A) Tank activity on the road 4 (B) This is a
4 Tanks stationary 5 Tanks stationary 1 Tank stationary 1 Truck 2½ ton 1 Vehicle on the road	46 & 67 57 66 67 & 88 27	19	8 Seconds (A) A vehicle at 55 (B) There is dirt roads with 2 objects

*with possible water trailer

TABLE 3B

COMPARISON OF UNTIMED AND TIMED REPORTS

UNTIMED (2 subjects working together after timed series)	SLIDE No.	TIMED (Independent reports of subject A and subject B)
1 Truck 58 1 APC, Truck, Jeep ea 55 4 APC's 48 2 Trucks 67 1 Piece UI Equipment 67 Old track activity Evidence of equipment present in wooded area	1	15 Seconds (A) Two tanks near 76 on the road and 55 (B) Track activity and dirt roads branching off with
1 Compressor truck mounted 59 2 Dozers 46 1 Truck, 2½ton, w/water trlr 54 1 Truck, 2½ton, ea 67 & 88 1 Truck, 3/4 ton 98 1 Truck, ¼ ton on road 65	59	30 Seconds (A) Two tank dozers at 36 & 46.A tank, eh truck on the road at 67. A vehicle parked at 59. One vehicle on the road at 65. A truck with trailer at 54 in the bend of the road. Two trucks at 88 (B) This is a vehicle - looks like a bull dozer at 63. Another at 64. Two vehicles up in the corner at 95. 2½ Ton truck at 76. A jeep at 56
1 Dye smoke marker 32 2 APC's 35 Area shows old track activity	21	60 Seconds (A) Two tanks at 35 stationary. Heavy track shown. Forest area at 73 thru 61. One vehicle at 58 - non tracked. Road running from 96 through 51, eh 59. (B) There is a vehicle at 52, and a lot of track activity with a dirt road running by upper right hand corner. There is also 2 more vehicles at 53. Looks like tanks at 27 among the trees, looks like a small vehicle, possible a jeep.

TABLE 3C

COMPARISON OF UNTIMED AND TIMED REPORTS

An Atypical Report Illustrating the Effects of a Combined Long Viewing-Exposure Period and a Slide with No Identifiable Targets

UNTIMED (2 subjects working together after timed series)	SLIDE No.	TIMED (Independent reports of subject A and subject B)
No military activity visible	69	60 Seconds (A) Tracked area showing vehicles in the road moving. Might be water puddles from 38 through 56. A vehicle on the road at 25. Forest area. Old track activity. Gravel pit in lower right corner. (B) This is a - looks like a something on a convoy small vehicles. Third class road going through the picture. Looked like small vehicles going along the right hand side of the road. Could be a convoy. Looks like something heavy to the rear.

TABLE 4

SAMPLE FLASH AND IMMEDIATE REPORTS FROM INTELLIGENCE SCHOOL READING

1.	34 - Vehicles parked in woods at DT 109413
2.	1 - AA/M,G, active in open field at DT 107404
3.	2 - Open emplacements, camouflaged AA or mortar ((at)) DT079411
4.	Vehicle park (occupied) ((at)) DT109413
5.	2 Probable camouflaged Arty pieces in ruins of house ((at)) DT103409
6.	AA/MG (occupied) ((at)) DT107404

TABLE 5

RANKING OF KINDS OF RESPONSES ACCORDING TO INFORMATION VALUE

1. I - Identified military objects

2. L - Locations of objects by coordinates

3. V - Identifications as unspecified military vehicles

4. UI - Identifications as unspecified objects of military interest

5. D - Descriptive nonidentifying terms such as, "large," "near," etc

6. G - General statements concerning gross features of some possible military interest

7. Q - Qualifiers such as "possibly," "maybe," etc

8. C - "Chatter" nonessential grammatically functional terms

In addition to these, there are so-called "error" responses.

9. E - Errors of several kinds, all involving identifications and locations of the first four kinds listed above (1 to 4), but for which the stimulus conditions include the following:

a. Military object ("substitution" error)

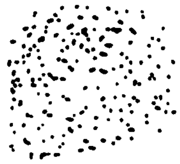
b. Man-made nonmilitary object ("inventive" error)

c. Natural objects ("inventive" error)

d. Imaginative error (no stimulus object)

TABLE 6

VARIABLES RELATED TO INTERPRETATION ERRORS

SETTING	STIMULUS OBJECT	VERBAL RESPONSE & KIND OF ERROR: FOUR CATEGORIES	VERBAL RESPONSE & KIND OF ERROR: MIL./NON-MIL. DICHOTOMY
MILITARY	APC *  OR OTHER NON-TANK MIL-OBJECT	"TANK" a.	"TANK" SUBSTITUTIVE
MAN-MADE NON-MILITARY	TRUCK (CIVILIAN)  OR-OTHER NON-MILITARY MAN-MADE OBJECT	"TANK" b.	"TANK" INVENTIVE
NATURAL	FOLIAGE  OR OTHER NATURAL OBJECT	"TANK" c.	
	SHADOW  OR OTHER VAGUE NON-OBJECT FORM		
	GANZFELD **  NO FORM	"TANK" d.	

* ARMORED PERSONNEL CARRIER

** SEE GLOSSARY

LETTERS IN COLUMN 3 CORRESPOND TO THOSE UNDER CATEGORY 9, TABLE 5.

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(DA Task Nr. 3D33-18-001-01) Unclassified report

A pilot experiment was conducted to determine preliminary estimates of interpretation performance at high rates of speed. Various factors of relevance in assessing such performance are discussed, using experimental results to illustrate their application. Requirements for a more comprehensive and statistically reliable experiment are outlined, and suggested areas for further research are discussed. The small number of samples of imagery and subjects made results only suggestive with respect to application.

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Two interpreters (subjects) were tachistoscopically shown 7 groups of 5 color slides of different portions of a surveillance area for 7 different combined viewing/response time periods.

Performance measurement is presented as a complex function of several factors, including conciseness, relevance, accuracy, and rate. These performance measures were applied to the experimental results for illustrative purposes only, and are not to be understood as implying higher reliability than is inherent in the statistically low reliability of the data. The tendency for redundancy of reports to increase with viewing/response time suggests that prior training of interpreters in rapid recognition and reporting would lead to improved performance.

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2. Imagery Interpretation
3. Performance Measures
4. Recognition Errors

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II. Army Electronics Research and Development Laboratory, Fort Monmouth, N. J.

III. DA Task 3D33-18-001-01

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